RAPHAEL ROSENBERG

EYE TRACKING AND ART HISTORY
DISCOURSE ANALYSIS AND EXPERIMENTAL RESEARCH

Pre-paper for the (second) seminar at the Italian Academy, March 6, 2024

I have worked with eye-trackers for 20 years and set up in 2006 the first eye-tracking lab in an art history department. My project at the Academy is to write a book about why and how art historians might want to experiment with these devices and consider the results of such experiments.

In my pre-paper in the fall, I presented a brief history of eye movements in art literature, explaining that they have recurred for almost two thousand years. In a seminar on Nov. 1, we discussed the results of eye-tracking studies conducted in my lab for Cognitive Research in Art History (CReA) at the University of Vienna. This pre-paper summarizes the previous pre-paper and the seminar to lay a common foundation for the March 6 seminar. Fellows from the fall semester and those who attended my talk at NYU on Feb. 22 are welcome to skim the first and second chapters.

1) Eye movements in art literature

The first part of my book analyzes the history of eye movements in art literature. It has been the focus of work at the Academy since September, and I just finished the first draft. I analyzed texts by hundreds of authors that I had collected over twenty years. It turns out that eye movements have been a topic of art literature for almost two thousand years. While evidence from late antiquity to the Renaissance is scattered, eye movements appear frequently in descriptions of paintings, sometimes also in descriptions of sculpture and architecture since the 1660s. The scope of most authors discussing eye movements is the "composition" of paintings, that is, the relationship between the parts of an artwork, especially in terms of form. The smooth path of the eye was an explanation of why artworks needed composition, and eye movements were an accessible description of the composition, avoiding the technical term, especially as long as this term was not in the general vocabulary (Fehrenbach, 2003 for a history of “composition” in the theory of painting).

André Félibien, the first professional art historian, was essentially responsible for popularizing the discourse on eye movements in art literature. In 1668, speaking about Nicolas Poussin's painting, *The Jews Gathering the Manna* (Fig. 1), he wrote: "the arrangement of the figures [of a painting] must be composed of parts, groups, and contrasts. […] The figures separated in various places of this painting share the gaze, giving it the means to somehow walk around these figures, [...] the groups serve […] to arrest the view so that it is not always wandering in a great expanse of country." (Félibien, 1668, p. 79 and 83)

Fig. 1: Nicolas Poussin
The Jews Gathering the Manna
1639

Beginning in the eighteenth century, descriptions of eye movements became more specific and were often used to provide detailed explanations of the composition of paintings. An early example is François Raguenet's description of Raphael's *Transfiguration* (Fig. 2), written in 1702: "The mother shows her suffering son to the apostles; the apostles, in turn, show this mother the summit of the mountain on which their master stands: the mother's action turns the eyes to the apostles; the apostles' action turns them to Jesus; and these two actions are so well connected that the painter's design is suddenly discovered and the story of the painting understood as soon as it is seen." (Raguenet, 1702, p. 229)

Fig. 2: Raphael, *Transfiguration of Christ*, 1516-20

Fig. 3: Raphael, *Saint Cecilia*, 1516-17

Most texts used eye movement to explain composition. Some authors went further, claiming that the composition should lead the viewer's eye in a continuous line, one singular path through the artwork. The first, as far as I can tell, was Michel-François Dandré-Bardon in 1765: "One of the main purposes of connecting groups is to lead the viewer's eye to the protagonist of the painting. This should be done diagonally. [...] Luminous echoes must be introduced, attracting the viewer's eye consecutively and leading it from one end to the other along diagonal lines [...] (Dandré-Bardon, 1765, p. 108 and 114f.). The main light must, as far as possible, present triangular shapes, a diagonal trace, and a successive chain in its progression so that the eye never loses the thread." In twentieth-century Germany, this approach turned into a dogmatic art history that claimed there was only one correct way to read works of art. In 1961, the German art historian Kurt Badt wrote: "It has been asked whether I am really forced to start somewhere in the picture, whether my gaze is free to 'fly around' in it at will. [...] But as a systematic basis for interpreting the work

of art as a whole and coherently in itself, the only possible sequence is from bottom left to top right because this is based on the essence of the picture's composition." (Badt, 1961, p. 40f.).

My first chapter focuses on the timeline and the discursive purpose of eye movement statements. I also tried to quantify the significance of this discourse. With the help of student assistants, I collected descriptions of selected paintings as comprehensively as possible and counted whether they mentioned eye movements. For Raphael's *Transfiguration*, we found 102 descriptions; of these, 16 discuss the viewer's eye movements (and it turns out that Raguenet was the first). This represents 15.7%. For Raphael's *Ecstasy of St. Cecilia* (Fig. 3), another altarpiece by the same painter, we found 48 descriptions, but only two, or 4.2%, discuss eye movements. I suspect the difference is because the composition of *St. Cecilia* is simpler: there is less incentive to describe the painting and less incentive to use eye movements in describing it. The survey also reveals that eye movements were more frequently mentioned in French and German, less so in Italian, and even less in English texts. This suggests that eye movements were also used as an idiom. An idiom that was more established in some languages than in others. While some authors may have been aware of using eye movements as an idiom, it is unlikely that all of them were.

2) Recording eye movements in the lab

At the end of the nineteenth century, ophthalmologists began to understand and, since 1898, to implement devices to record eye movements. It turned out that the eye must remain still to perceive stationary objects and that we perceive only a tiny radius in focus and need to move the eye to focus on further details. Our eyes always alternate between fixations (approximately 300 ms) and rapid, blind movements called "saccades" (approximately 50 ms). Gazes smoothly following the composition of a painting were thus deemed obsolete; art literature and art history were at odds with ophthalmology.

Since I had access to an eye tracker (a device that records eye movements), this contradiction became a major focus of my research. It took several years to develop a model for quantifying composition and comparing it statistically with oculometric parameters. In one experiment, we showed high-resolution reproductions of 14 images of the same topic – the Last Supper, created between the twelfth and seventeenth

centuries, each with very different designs. 32 participants – second- and third-year BA students – looked at each for 60 seconds in random order while their eye movements were recorded. They were then asked to draw the composition of each image on a tablet using a maximum of five lines. The following drawings are examples of the compositional lines drawn by some of the participants on the oldest image we have used:

Fig. 4a-c: Three compositional drawings on Nicolas de Verdun, *Last Supper*, 1181

The participant in Fig. 4a drew a cross, connecting the heads of the apostles, while the one in Fig. 4b drew a diagonal line along Judas' bent body and a second perpendicular diagonal connecting some heads to the hand of an apostle. Both emphasize figurative elements such as the direction of the bodies, the course of the limbs, gestures, prominent objects, and the relationships between them. This is not the case for the participant in Fig. 4c: she drew the central horizontal, the two major large main diagonal lines of the picture ground, and completed the central arc to form an oval extending to the main diagonals.

Fig. 5 illustrates the overlay of all drawings from 32 participants. It shows that the participants differ but that there are also strong similarities between the drawings. By overlaying this cumulative drawing with a grid (Fig. 5b) and counting the number of parallel vs. non-parallel lines in each cell, we defined a similarity coefficient that can be calculated by an algorithm that averages the results of different grid sizes (Sancarlo et al., 2020with statistics and more visualizations). The similarity coefficient of compositional drawings was higher for some images (Fig. 7b), lower for others (Fig. 8b), and significantly above chance for all.

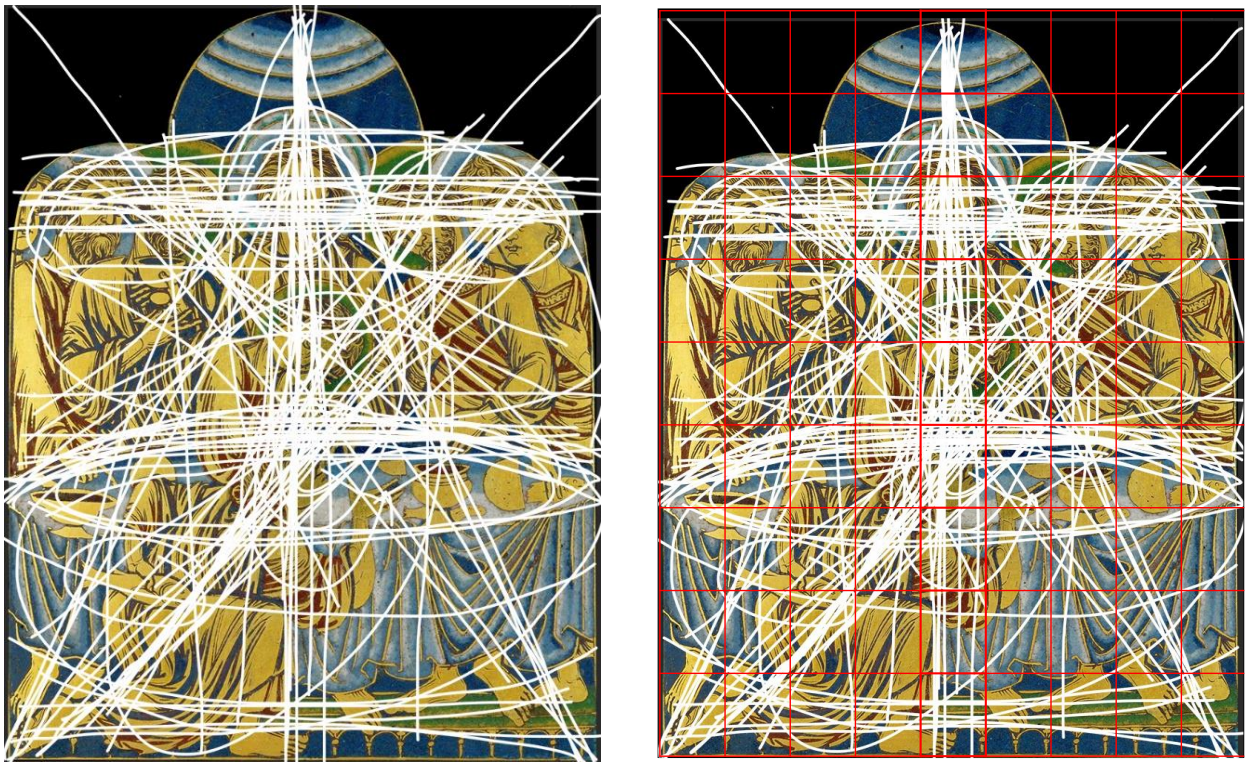

Fig. 5a-b: Overlay of the compositional drawings of 32 participants, b: with a 9x9 grid

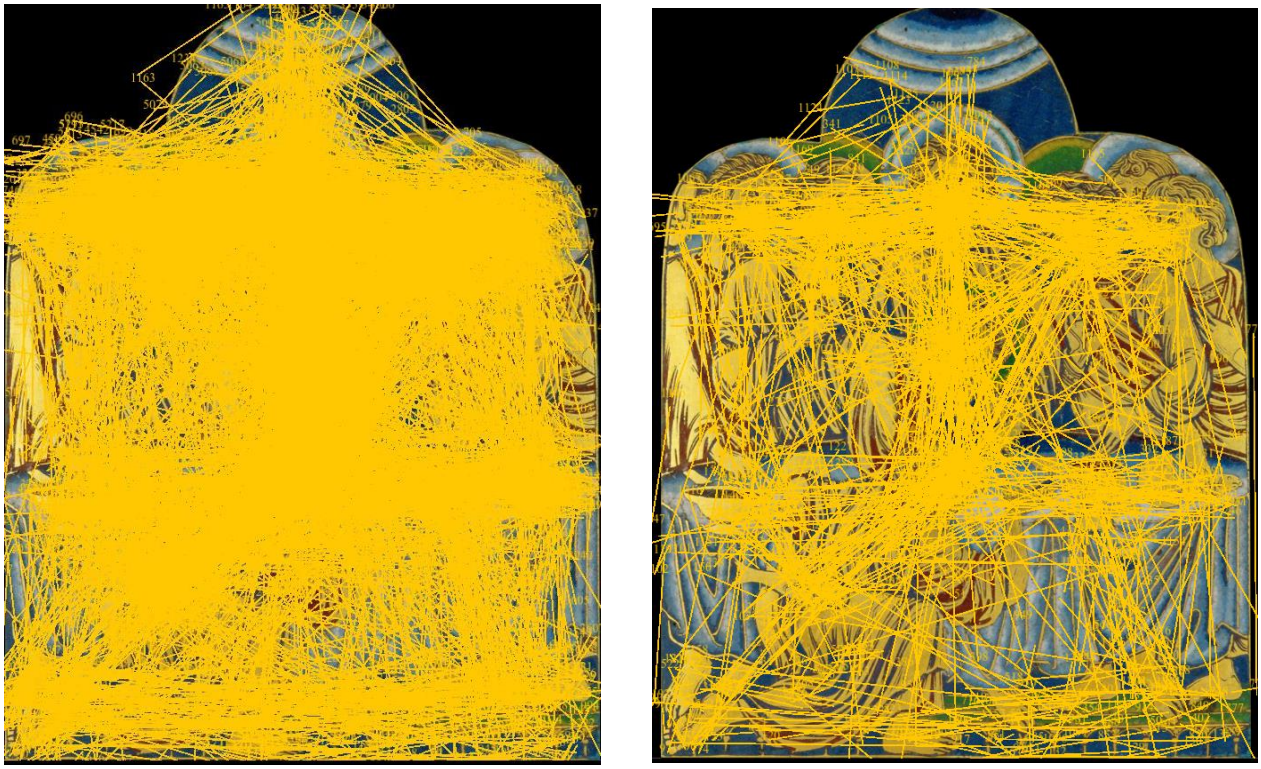

Fig. 6a-b: Saccades of 32 participants looking at Nicolas de Verdun's *Last Supper* for 60 sec.,
b: 1/3 of them (to better visualize patterns)

In a second step, we analyzed participants' eye movements, i.e., saccades of the, a parameter that receives less attention in oculometric research than fixations. We defined saccades as lines between two fixations (Figs. 6a-b). Using the same method of superimposing a grid, we calculated similarity coefficients for the saccades of the participants looking at the same image. Again, the similarity coefficient was consistently significantly higher than chance. This means that different people looking at the same picture make similar eye movements.

The third step was to compare saccades and compositional drawings. We used the same grid method and algorithm. It turns out that saccades and compositional drawings are significantly similar for most images. However, there are notable differences. The similarity is very high for Castagno (Figs. 7b-c), lower for Nicolas de Verdun (Figs. 5a and 6b) and Tintoretto (Figs. 9b-c), and below chance for Bouts (Figs. 8b-c). After discussing these comparisons in the Academy's fall seminar, I have looked at the visualizations again and more thoroughly, and I think I can now better explain the reasons for differences: Eye movements follow figurative elements in the pictures, but they do not run along other types of compositional lines – neither the lines dividing the ground of the picture (as in Fig. 4c and, very often, Fig. 8b), nor along the construction lines of one-point perspective (as in Figs. 8b and 9b).

What do we learn from this eye-tracking study of *The Last Supper*? First, painterly composition is not an objective feature, but it can be used for analysis of artworks because there is a statistically significant degree of intersubjective agreement. Second, eye movements and composition correlate, though not as linearly as art literature since Félibien suggests. Third, art historians use the term "composition" to refer to for (at least) three different things: a) the linear directions of painted elements and the formal relationships between them; b) the structure of the picture ground; and c) the lines of perspective construction. While a) corresponds with unconscious eye movements, i.e. primary physiological perception, b) and c) depend more on conscious, higher cognitive processes.

3) Other studies and why they matter

Students and post-doc researchers in my lab use eye trackers in three lines of research:

First, we study correlations between features of artworks and oculometric parameters. For example, we are looking at differences between abstract and representational artworks. We are investigating whether eye movements differ when looking at artworks that are perceived as dynamic, and whether this depends on the source of the dynamism (representational motion versus dynamic brush strokes). We study how symmetry affects eye movements (a study of book-matched marble slabs). We analyze gaze directions (painted eyes) and pointing gestures in early modern history paintings: do viewers follow them, and does it depend on whether the participants are used to looking at such pictures? Do deaf signers, who usually focus more on gestures but are less familiar with early modern history paintings, look at them differently? There is a recurring idea in art history about two fundamentally different modes of seeing: perceiving the three-dimensional represented elements of a picture versus looking at the shape of the painted surface. Richard Wollheim formulated them as "seeing-in" versus "seeing-as", Max Imdahl as "wiedererkennendes Sehen" (recognising seeing) versus "sehendes Sehen" (seeing seeing). We investigate whether these two ways of seeing are (only) a theoretical model or whether they actually alternate in the process of art perception.

Is it important to determine the physiological correlates of art historical categories? Are we as naive as Franz Joseph Gall, the physiologist who invented phrenology? Co-fellow Giandomenico Iannetti brought this question to my mind by drawing my attention to György Buzsáki, who accuses neuroscience of unconditionally adopting William James' psychology and focusing on identifying the underlying neuronal mechanisms in James' terms (Buzsáki, 2019, p. 6f.). Psychologists and ophthalmologists have studied eye movements in detail. But mostly only in the first seconds of perception. Those that are relevant to everyday life. However, the perception of works of art and "aesthetic" perception, which is not limited to works of art, is characterized by a prolonged viewing period of several seconds to several minutes. What happens during this prolonged viewing? We know little about this, and I think it is important – for art history and for a better understanding of the nature of aesthetic pleasure. Visual art cannot exist without the eye, just as music cannot exist without the ear. Art does not happen in the eye, but the creation and reception of works

of art always pass through the eye. Understanding whether, how, and to what extent categories used to analyze artworks correlate with specific eye movements provides a better understanding of those categories. Studying the eye movements of the *Last Supper* paintings allowed for a more nuanced understanding of "composition".

Second, we test for differences between groups of viewers. We have found that age matters, but not gender. We are particularly interested in expertise and culture, because they point to possible differences between viewers in different historical periods. This is a great challenge for art historians who study art from the past and from different cultures. I will share insights at the panel on *Attention and Attunement* at the Academy on March 29.

Third, we are using mobile eye trackers to test art perception in the museum and how different displays affect us. Mobile devices are young and evolving rapidly. They have been available for about ten years and now provide data with high accuracy and reliability, but they still pose significant challenges for data analysis. This is the topic of the March 6 seminar.

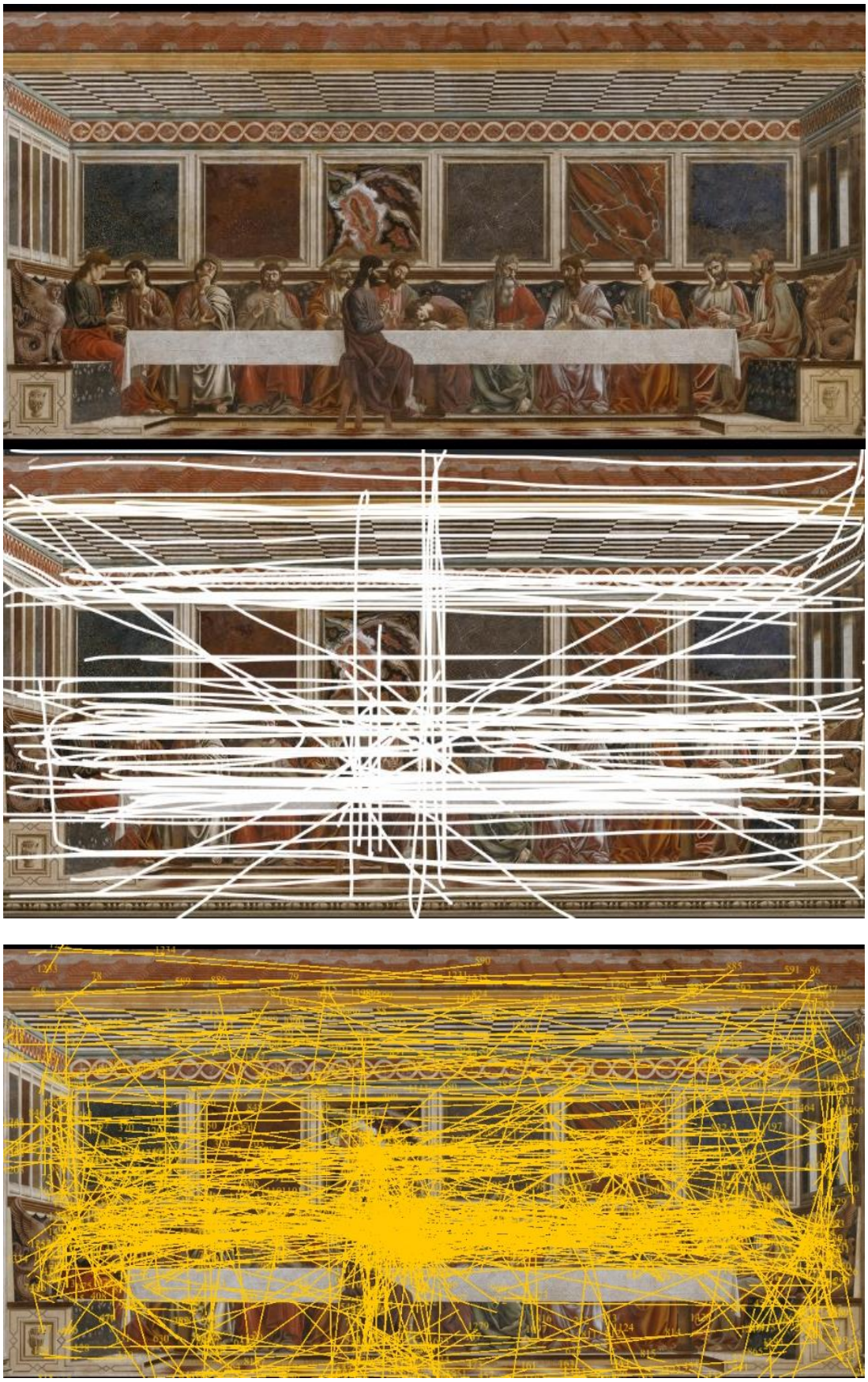

Fig. 7a-c: Andrea del Castagno, *Last Supper*, 1445-50, b: with composition drawings of 32 participants, c: with 1/3 of the saccades of 32 participants looking for 60 sec.

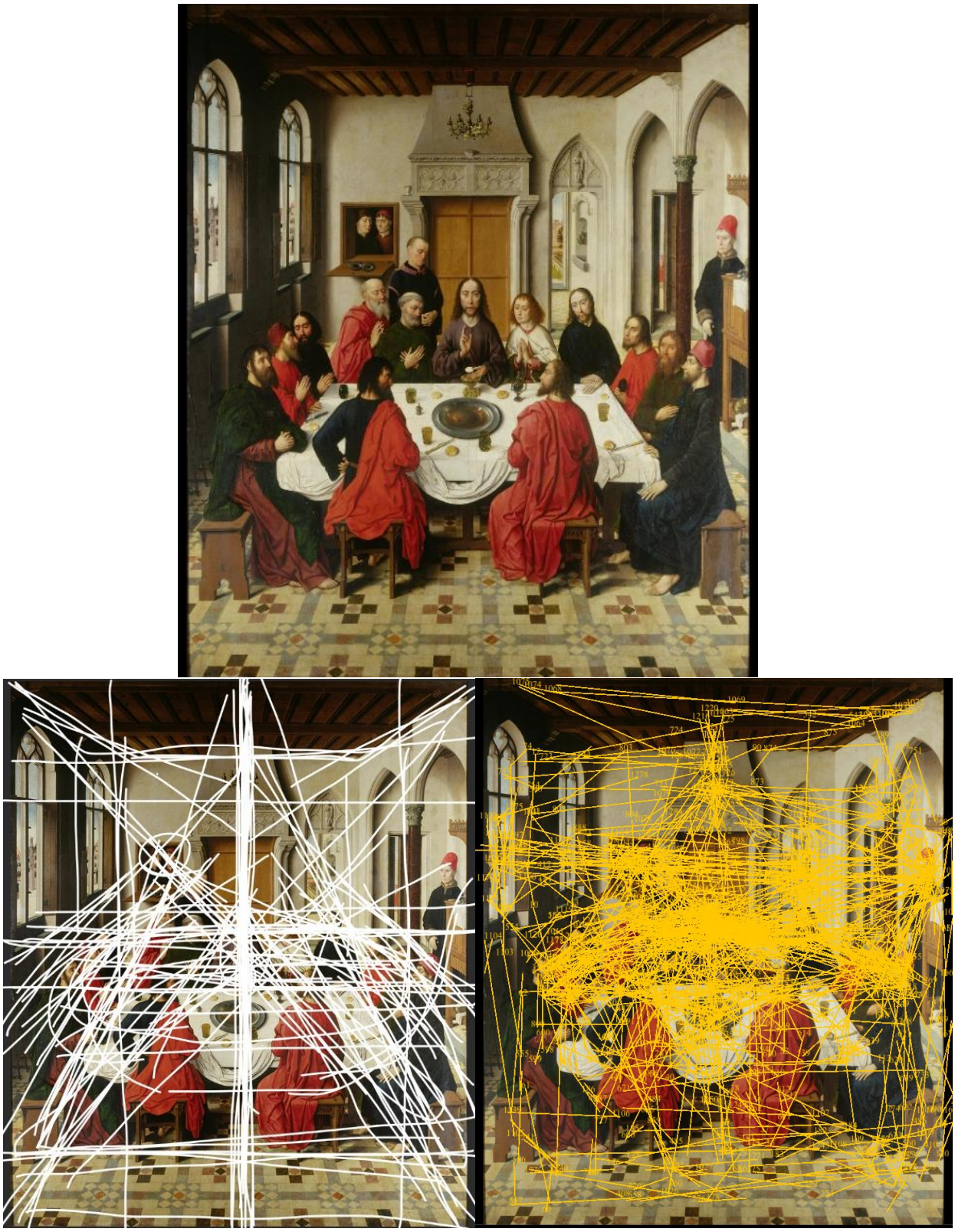

Fig. 8a-c: Dieric Bouts, *Last Supper*, 1465, b: with composition drawings of 32 participants, c: with 1/3 of the saccades of 32 participants looking for 60 sec.

Fig. 9a-c: Jacopo Tintoretto
Last Supper, 1592
b: with composition drawings of 32 participants,
c: with 1/3 of the saccades of 32 participants looking for 60 sec.

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